Atmospheric Densities from Explorer 17 Density Gages and a Comparison with Satellite Drag Data

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The purpose of this letter is to present the initial atmospheric densities directly measured by the ionization gages on the Explorer 17 satellite. The satellite has been described [*Horowitz,* 1963] and the gages and their response to the atmosphere have also been reported [*Newton et al.,* 1963]. The data presented in this letter were obtained with two types of ionization vacuum gages, the hot-filament thermionic type (Bayard-Alpert) and the magnetron type (Redhead). The absolute accuracy of these data is believed to be ±35% and the repeatability is ±20%. A more complete discussion of the experiment will be included in a paper now in preparation [*Newton et al.,* 1964].

The density data from 47 operations of the satellite in the altitude range 255 to 330 km for local times between 0700 and 2100 hours are plotted as a function of altitude in Figure 1. These data were recorded by the five northern midlatitude minitrack stations:

Blossom Point, Md.
Grand Forks, Minn.
Majove, Calif.
St. Johns, Newfoundland
Winkfield, England

At the times the measurements were made, the daily planetary geomagnetic index (A_p) was between 0 and 50, and the 10.7-cm solar index ($F_{10.7}$) was between 70 and 100 $\times$ 10^{-22} w/m² cps. It is seen from Figure 1 that there is considerable variation in the atmospheric density at a given altitude (that is, greater than a factor of 3 at the altitude of 280 km) which is due in part to local time, geomagnetic activity, and solar activity effects.

To compare the directly measured densities with densities inferred from satellite drag, it is desirable to reduce the data to geomagnetically quiet conditions. In this regard, consider Figure 2, which shows $\Delta \log \rho$, the logarithm to the base 10 of the ratio of the measured density to the Harris and Priester model density selected for the appropriate time and altitude, plotted versus the daily geomagnetic index (A_p). These points represent 120 density-altitude profiles for altitudes between 255 and 600 km and most local times; the data were recorded over the same five minitrack stations as were the data in Figure 1. The darkened symbols represent an average of two or more passes within

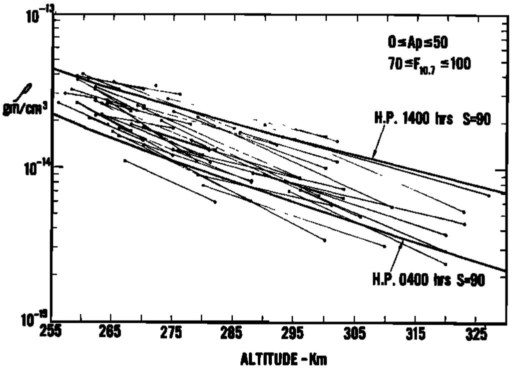

Fig. 1. Atmospheric density versus altitude measured by the Explorer 17 density gages during 47 operations of the satellite. The densities were measured for times between 0700 and 2100 hours, with A_p varying between 0 and 50 and with $F_{10.7}$ varying between 70 and 100 $\times$ 10^{-22} w/m² cps.

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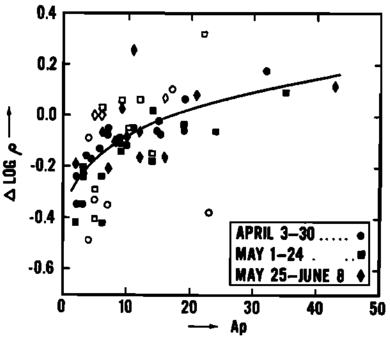

Fig. 2. Daily average of the logarithms of the ratios of the gage measured density to the Harris and Priester model density, plotted against daily geomagnetic A_p index. Solid symbols represent averages of measurements obtained from two or more passes of the satellite over the telemetry stations. Open symbols represent single passes. The data have been adjusted to correspond to $F_{10.7} = 83$. The semiannual variation of the atmospheric density has been accounted for in an approximate way by decreasing the model densities by 18% for May and June 1963.

one day and the light symbols represent one pass. The passes have been individually corrected to an $F_{10.7}$ of 83 using *Roemer*'s [1963] formula. The semiannual variation of the atmospheric density has been accounted for in an approximate way by decreasing the model densities by 18% for May and June 1963. A visual average of the data shows (*a*) that the relation between Δ log ρ and A_p is nonlinear, the steepest slope being applicable to the smaller A_p values, and (*b*) that the atmospheric density values are more sensitive to geomagnetic disturbances than has previously been reported. Very recently, *Jacchia and Slowey* [1964*a*] found independently that for near-quiet geomagnetic conditions the reaction of the atmosphere to variations in A_p is considerably larger than that expected on the basis of their previous analyses.

Figure 3 shows the logarithm to the base 10 of the gage densities at the average time and altitude of the pass plotted versus local time and normalized to 280 km using the Harris and Priester model for $S = 90$ as a differential altitude transformer. Shown for comparison are the densities obtained from drag observations of Injun 3 [*Jacchia and Slowey*, 1964*b*] and Explorer 17 [*Bryant*, 1964], and the Harris and Priester model with $S = 90$. The drag data have also been normalized to the 280-km altitude.

The Injun 3 drag data, indicated by squares, were selected for quiet geomagnetic conditions ($A_p \leq 2$) for the time interval of February 18 through June 30, 1963, when the latitude of the satellite varied between $-40°$ and $+60°$. The Explorer 17 drag data, indicated by crosses, correspond to the time interval from April 3 to July 6, 1963, when the satellite perigee was between $+58°$ and $-20°$.

The relation shown in Figure 2 has been used to adjust both the Explorer 17 drag-determined and gage-measured densities to geomagnetically quiet conditions ($A_p = 2$). The Explorer 17 densities also have been normalized to a 10.7-cm solar index of 83, a small adjustment compared to those associated with the A_p. The A_p adjustment resulted in: (*a*) a decrease of approximately a factor of 2 in the apparent scatter between the gage-measured density values, (*b*) a lowering of the average of the gage-measured densities by a factor of 0.7, and (*c*) a lowering of Bryant's drag densities by approximately 60%.

It is seen in Figure 3 that the atmospheric densities determined by satellite drag techniques appear to be systematically higher by a factor of 2 than the adjusted gage densities. This difference is greater than the combined uncertainties assigned to the separate sets of data and would seem to be due to a systematic error in one or both of the measurements. While the difference is not regarded as a serious discrep-

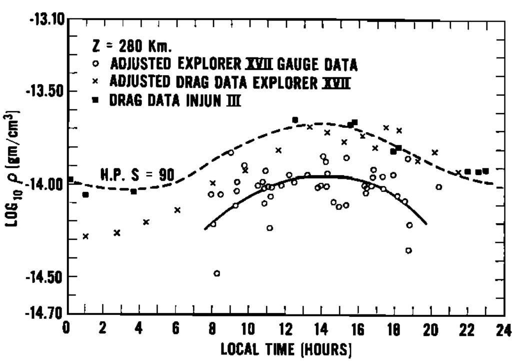

Fig. 3. Logarithms of densities normalized to an altitude of 280 km versus local time. Injun 3 data are selected for geomagnetically quiet conditions. Explorer 17 data are adjusted to $A_p = 2$ using relation shown in Figure 2 and for an $F_{10.7}$ corresponding to 83.

ancy between the two techniques, it is large enough to require a re-examination of the measurements made by each.

A more detailed presentation of the atmospheric density data from these five minitrack stations and their geophysical interpretation is in preparation [*Newton et al.*, 1964]. The presentation will include (1) data of considerably greater altitude and local-time coverage and (2) density scale-height computations. In addition, data from the other eight minitrack stations for the complete Explorer 17 orbit (perigee 255 km, initial apogee 920 km, 58° inclination) are currently being analyzed and will be reported.

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